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The doors of perception

The use of VR in psychology experiments is being driven not just by increasingly affordable technology but also by concerns about the reproducibility of many real-world psychology experiments. But do humans really behave in the virtual world as they would in the real? And does it matter? David Matthews investigates

I'm waiting in a grey, bare corridor that wouldn't look out of place in a slightly neglected hospital or university. Out of nowhere pops a snarling wolf, less than a metre from my face. I recoil, but, within a split second, it has vanished. I brace for the next surprise. A huge tarantula appears to my left, then disappears. Then a snake to my right. Then a chicken at my feet.

My hands sweat slightly with anticipation as I await the next creature. They are obviously not real: they look like they were imported from a decade-old computer game, and I can feel the bulk of a virtual reality headset pressing on my head and the bridge of my nose. But my fear response most definitely is real. And, for the researchers watching me, that is the important point.

They hope to measure whether I think that the threatening animals appear closer than the non-threatening one, and whether this psychological quirk changes with the cycles of my heartbeat. And virtual reality technology allows them to take a "small step" away from traditional, computer monitor-based experiments and simulate something closer to the

real world, says one of my tormentors, Felix Klotzsche, a doctoral researcher at the Max Planck Institute for Human Cognitive and Brain Sciences in Berlin.

The use of virtual reality in psychology studies is becoming increasingly commonplace. No one knows exactly how many labs have taken it up, but "people don't raise an eyebrow so much when you're using it" now, says Cade McCall, a lecturer in psychology at the University of York. And Antonia Hamilton, professor of social neuroscience at UCL, estimates that every psychology group at Russell Group universities in the UK now has at least one VR system.

McCall himself has been experimenting in VR for 15 years, but its wider proliferation has been made possible by the release in 2016 of several commercially available, high-quality headsets, like the Oculus Rift and HTC Vive. "Back in the day, a head-mounted display cost $35,000 (£26,413)," he reminisces. "Now you can pick up [a headset] for less than $1,000: anybody can have a VR lab."

Not only that but, with VR going more mainstream, technical troubleshooting support has improved, and the software to create virtual worlds is now far easier to use, researchers report.

But it isn't just technology that is driving the use of VR. This past year, a number of psychologists and neuroscientists have begun to argue that it can open up new research frontiers – allowing them to simulate LSD trips or out-of-body experiences, for example – while, crucially, adding much-needed reproducibility to the experiments.

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"VR offers the best of both worlds," wrote Stephan de la Rosa and Martin Breidt, both researchers based at the Max Planck Institute for Biological Cybernetics in Tübingen, last year. Placing people in customisable, controllable VR worlds offers "full experimental control" amid "realistic environments" that boost the "ecological validity" of the results, they argued, in a commentary for the *British Journal of Psychology*, titled: "Virtual reality: a new track in psychological research".

The technology has come to prominence just as psychology is facing a crisis of credibility, following several failed attempts to reproduce some of its most prominent studies. The latest of these, published in November, managed to reproduce only 14 out of 28 studies. "Ironically enough, it seems that one of the most reliable findings in psychology is that only half of psychological studies can be successfully repeated," *The Atlantic* concluded.

No one expects VR to be the silver bullet that solves all these problems. Yet advocates see numerous advantages. First, VR experiments should be much more replicable than working with flesh-and-blood actors who are asked to play a particular role in an experimental set-up but may unwittingly introduce subtle variations in how they act and speak between iterations.

"You never really know what's happening during that interaction," says Sylvia Xueni Pan, a lecturer in VR at Goldsmiths, University of London, and co-author of "Why and how to use virtual reality to study human social interaction: the challenges of exploring a new research landscape", a guide for researchers published last year in the *British Journal of Psychology*. "Even the best actors can't control what they do," she adds, given that humans also communicate subconsciously, via gaze, head movements or blushing.

Virtual environments, on the other hand, can remain identical from participant to participant, and lab to lab. "If you have the same kit, and the same code, you should be able to repeat these experiments," says Anil Seth, professor of cognitive and computational neuroscience at the University of Sussex, who has conducted several experiments in VR.

Moreover, in VR, researchers can fine-tune exactly what changes from situation to situation, isolating specific variables. They can tweak only the colour of an avatar's skin, for example, to see if this makes any difference to interaction. Such exact control is not possible when using actors as finding two who are identical except for their ethnicity is all but impossible. And a third advantage is being able to put people in situations that would be dangerous, unethical or downright impossible in real life, but that would lack any kind of realism or immersion if simply displayed on a screen.

In one of McCall's experiments, designed to test how people cope with anxiety, volunteers are placed in a VR "Room 101", which fills with giant spiders, is splattered with blood and collapses floorboard by floorboard into a pit, before one final man-sized tarantula is unleashed on to the participant. "It's hard to imagine doing something like what we did [in real life] without being grossly unethical," says McCall.

It would also be immensely expensive. Researchers could build a haunted house at the cost of hundreds of thousands of dollars, he speculates, but VR is a much easier way to get the heart pounding with terror. Compared with other tools at psychologists' disposal, such as viewing spiders on a flat computer screen, VR is like a "sledgehammer" for generating emotions like fear, he says.

The technology has also been used to study less scary paranormal experiences, such as out-of-body experiences – which, under some conditions, has reduced the subjects' fear of death.

A final advantage of VR is that it "brings the body into the picture", explains Sussex's Seth. Some VR kits – although not yet commercially available – can track the subject's entire body, meaning that their VR body moves as they do. "We can manipulate experiences of embodiment in all sorts of ways. We can give people virtual hands of different sizes, shapes and colours," Seth enthuses.

In his latest experiment, volunteers were

able to see virtual versions of their arms in VR. Sometimes these virtual arms moved to press a button, despite their real arms staying still. This allowed the team to check whether an action that they didn't make is perceived in the same way as one that they did make. "We couldn't do this without VR," he says.

Some researchers have combined EEG sensors with VR headsets to track brainwaves, while new kits released this year will include eye-tracking, too. Such fine-grained monitoring "allows analysis of implicit and natural behaviours that may show much more subtle and interesting effects" than traditional computer-based methods, according to the guide to using VR written by Goldsmiths' Pan and UCL's Hamilton. Reacting to what is happening on a traditional computer screen, by contrast, is "nothing like what we do in the real world", she says.

But the big question hanging over VR is whether it is any better at casting light on how we behave in real life. I might flinch in the face of a virtual wolf – but a real one would surely provoke a rather stronger reaction. And can sharing a space with a virtual avatar ever compare to being in the same room as a flesh-and-blood human?

Alan Kingstone, a psychology professor at the University of British Columbia, is one of those investigating this question. In one experiment, Kingstone and colleagues examine the extent to which the presence of other people inhibits contagious yawning. This is known to occur in standard laboratory settings, but the researchers found human avatars in the virtual world did not have the same effect. By contrast, people wearing a VR headset were less likely to contagiously yawn when a real researcher was present in the room – even though they could not see or hear them. "Social cues in actual reality appear to dominate and supersede those in VR," concludes the resulting paper, "Contagious yawning in virtual reality is affected by actual, but not simulated, social presence", published in January in *Scientific Reports*.

Now, Kingstone and colleagues want to discover whether other results gleaned in VR repeat in real life (and vice versa). Fear that they do not has made him "a little disillusioned" with his earlier psychological work done in VR.

For a start, VR graphics are just not yet convincing, he argues; they resemble a "weird dream, like nothing is real". The idea that VR is comparable to real life is a "bit of a stretch at the moment", he thinks. Take underwater VR experiences, where people are lowered to the seabed inside a virtual diving cage. People seem genuinely afraid when virtual sharks swim towards them – yet never think to hold their breath. Kingstone's hunch is that some responses to virtual worlds mirror those in the real world while others do not, since, using current VR technology, subjects are "immersed but not immersed".

To be fair, researchers who deploy VR in their experiments do not claim that it provokes the same responses as full reality. "When I throw spiders at people in virtual reality, I know it's a different response from what I would get in the real world if I threw an actual spider in their face," concedes McCall. But "I sure as hell can get an emotional response", he adds – meaning that it can still be useful for study.

Seth agrees. "You go and see something at the cinema – of course you know it's not real. But that doesn't stop the narrative drawing you in," he says. It is a "false aspiration" to hope that VR can ever evoke the same response as reality. But "it is its own thing, and will be a useful complement to experiments in the real world", he insists.

VR use is now "quite well developed" in studies of spatial cognition, where participants have to find their way through a maze, for example, explains Hamilton. But it is "very, very challenging" to create human-like avatars that can interact with people in VR, she warns.

Her guide to using VR looks forward to the development of technology that can pass a "VR Turing test" by generating a virtual avatar that behaves so realistically that the subject cannot tell whether it is controlled by artificial intelligence or a real human in the next room. But this is still some way off: "50 years, maybe", speculates Hamilton.

There are other ways to fool people into thinking that VR is real. Seth, along with colleagues including postdoctoral research fellow Keisuke Suzuki, are experimenting with what they call "substitutional reality". Participants are told to sit in a room and wear a VR headset that nonetheless allows them to see the real world around them through front-facing cameras. But without telling them, and without the participants noticing, this live feed is at some point secretly switched for a pre-recorded panoramic video of the very same room, created earlier.

Then you can start to make unusual things appear in the room, Seth explains with a chuckle. "How much do people notice about weird things happening? If you're not paying attention to something, it can change massively and you won't notice," he says.

Aside from the challenge of believably simulating reality, there are also more mundane, practical problems with existing VR. Headsets can be uncomfortable if worn for long periods, while motion in VR can make some people feel dizzy, says Michael Gaebler, a cognitive and neuroscientist at the Max Planck Institute for Human Cognitive and Brain Sciences. In clinical settings, he worries, this might put patients off using VR treatments, such as for pain or phobias. VR "still has to prove its value", Gaebler concludes.

The situation is not helped by the fact that psychologists are still only using the very earliest generation of commercial headsets. But expectations are high within the industry that the next decade will see dramatic improvements in graphics, sound, field of view and tactile hand feedback.

VR visionaries have long thought that the technology could have untold benefits for researchers. Jaron Lanier, the US computer scientists who coined the term "virtual reality", wrote in his 2016 book, *Dawn of the New Everything: A Journey Through Virtual Reality*, that VR is "the farthest-reaching apparatus for researching what a human being is in…terms of cognition and perception".

So far, though, its potential for psychology and neuroscience has only dimly begun to come into view. "VR has not yet overturned existing assumptions" about how humans behave, admits the Max Planck Institute's de la Rosa: this step change in research is still only "at the very beginning".

Yet even if we don't behave in virtual worlds exactly as we would in the real world, this does not mean that virtual behaviour is unimportant. After all, in 20 years' time, we could be spending more time interacting with others in virtual worlds than in the real one, thinks Goldsmiths' Pan. Hence, like our behaviour on social networks, our in-VR behaviour is "definitely" worth studying, she says.

"In the future, more and more places will be using VR for training and education," she predicts. "And we absolutely need to understand what we are getting ourselves into." ●